

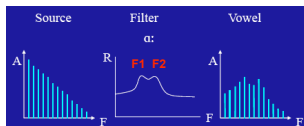
Review of Lab 2

Formant analysis of vowels

Source-Filter Model

- **Source-Filter model** describes speech sound production in terms of independent **source** and **filter**.
 - Explains separation of **pitch** and **timbre** for vowels.
- For vowel sounds, the **source** of sound is the regular vibration of the vocal folds in the larynx and the **filter** is the whole vocal tract tube between the larynx and the lips.
 - **Vowel Source**: The periodic buzz produced by the vibrating folds has a large number of harmonics.
 - **Vowel filter**: Characterised by small number of resonances called **formants**.
- Relationship exists between **formant frequencies** and **articulatory phonetic description** of vowels.
 - **F1**: Associated with increasing **openness** of vowel articulation
 - **F2**: Related to increasing **frontness** of vowel articulation

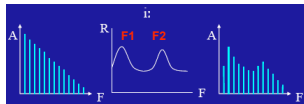
Source-Filter Model



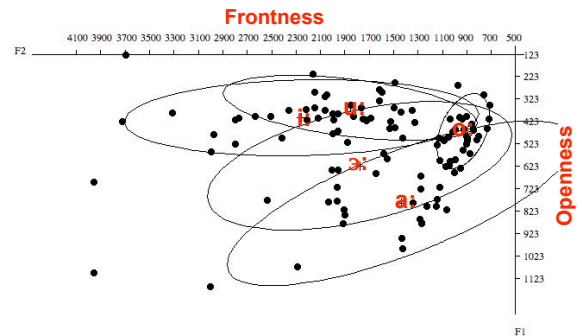
Source: Sound generated by larynx vibration. Spectrum contains many frequency components, with more energy at lower frequencies.

Filter: Vocal tract pipe changes quality of source. Some frequency components emphasised in passage through vocal tract pipe.

Vowel: Sound radiated from lips

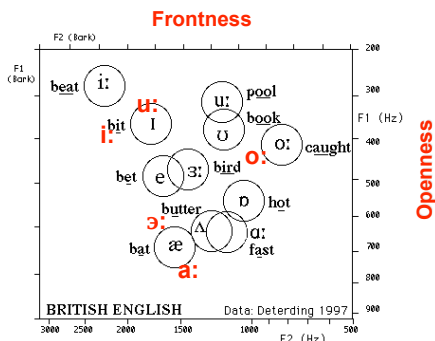


F1-F2 Charts from Lab 2



Formant-plotting software:
<http://www.linguistics.ucla.edu/people/grads/billerey/PlotFrog.htm>

Comparison to Deterding (1997)



Five male and five female BBC broadcasters

Average adult male formant frequencies of British English vowels

25 male speakers of British English (Received Pronunciation):

Vowel	F1(Hz)	F2(Hz)	F3(Hz)
heed	280	2620	3380
hid	360	2220	2960
head	600	2060	2840
had	800	1760	2500
hudd	760	1320	2500
hard	740	1180	2640
hod	560	920	2560
hoard	480	760	2620
hood	380	940	2300
who'd	320	920	2200
heard	560	1480	2520

Wells, J. C. (1960). A study of the formants of the pure vowels of British English. MA thesis. UCL.

Vowel Variation: Accent

- Accents are patterns of phonetic variation that recur within a group. They help us identify individuals which belong/do not belong to our group: geographic or socio-economic.
- Much accent variation involves changes in vowel quality (same vowel phoneme, different vowel qualities), although there may also be differences in consonant quality, duration, intonation and voice quality.
- Speaker makes articulatory choices for particular phonemes to match group.
- Vowel quality variation can be studied by measuring formant frequencies.

Vowel Variation: Reduction

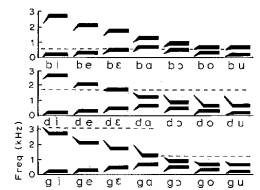
- English utterances have a rhythmic pattern which differentiates "stressed" from "unstressed" syllables.
 - Stressed syllables are longer and more carefully articulated.
 - Unstressed syllables are shorter and less carefully articulated (called reduction).
- Exact articulation (and hence quality) of a vowel can therefore depend on whether vowel is in a stressed or unstressed syllable.

Vowel Variation: Speaker

- Speakers have different sized vocal tracts.
 - This affects the absolute formant frequencies.
 - Although patterning is similar within one accent.
- Speakers may have unusual pronunciations (w.r.t. their accent) for just a handful of uncommon words.
 - Experience of words that you've read that you've never heard spoken!

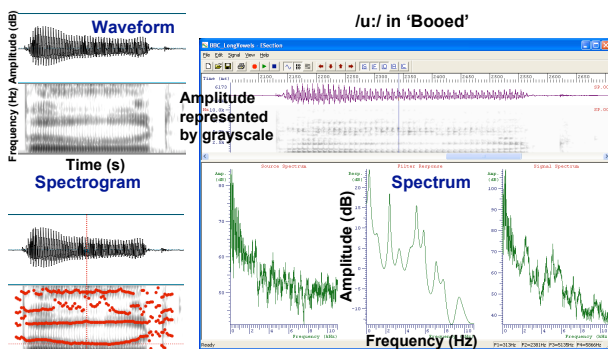
Vowel Variation: Dynamics

- In speaking, the articulators are moving all the time.
 - E.g. the tongue has to move from making some consonant into position for some vowel and on to the position for the next consonant.
- Therefore the exact articulation for a vowel can depend on what consonants come before and after it.



Delattre, P. C., Liberman, A. M., & Cooper, F. S. (1955). Acoustic loci and transitional cues for consonants. *Journal of the Acoustical Society of America*, 27, 769-773.

Vowel Variation: Measurement error



F1: 297 Hz, F2: 852 Hz
F3: 2429 Hz

F1: 313 Hz, F2: 2381 Hz (F3 actually)